U.S. Department of Commerce

NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN

VOLUME 46 JANUARY 1962 NUMBER 1

spectra of extra-terrestrial radicals

U.S. DEPARTMENT OF COMMERCE — LUTHER H. HODGES, *Secretary*

NATIONAL BUREAU OF STANDARDS — A. V. ASTIN, *Director*

NATIONAL BUREAU OF STANDARDS

Technical News

BULLETIN

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, 25 D.C. Subscription price, domestic $1.50 a year; 75 cents additional for foreign mailing; single copy, 15 cents. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (June 19, 1961).

January 1962 — Issued Monthly — Vol. 46, No. 1

Contents

	Page
Determination of the Spectra of Extraterrestrial Radicals	1
Miniature Helium Expansion Turbine with Gas-Lubricated Bearings	2
Special International Program Established	3
Comparative Measurement of Pulse Amplitude	4
Radio Refractive Index Data Center	5
1961 Technical Session on Bone Char Research	5
Wildhack Named Associate Director	7
An Improved Resistance Thermometer Bridge	8
Certification of Haemocytometer Cover Glasses Discontinued	10
Improved Rectifier Circuits	10
Evaluation of Contrast in Test Charts	12
1962 Electromagnetic Measurements Conference	13
Superconductivity Maintained Under High Magnetic Field	14
Estimating the Stage of the Sunspot Cycle	15
National Conference of Standards Laboratories Established	17
Publications of the National Bureau of Standards	18

COVER: The National Bureau of Standards is making measurements to determine the frequencies at which radiotelescopes can most effectively search for free radicals in outer space. Detection and study of extraterrestrial spectra other than the well-known 21-cm line of hydrogen would add greatly to knowledge of interstellar gas clouds and perhaps of planetary atmospheres. This absorption cell, shown between the poles of an electromagnet, has been used for paramagnetic absorption studies of the long-lived OH radical. Dr. H. E. Radford, who is conducting the measurements, can be seen reflected in the metal face of the magnet.

Determination of the Spectra of Extraterrestrial Radicals

THE DETECTION and study of extraterrestrial spectra other than the well-known 21-cm line of hydrogen would contribute greatly to our knowledge of interstellar gas clouds and perhaps of planetary atmospheres. To make radiotelescopic searches for such spectra feasible, however, it is necessary to minimize the bandwidth of the receiver. This can be accomplished only if the line frequencies to be detected are accurately known.

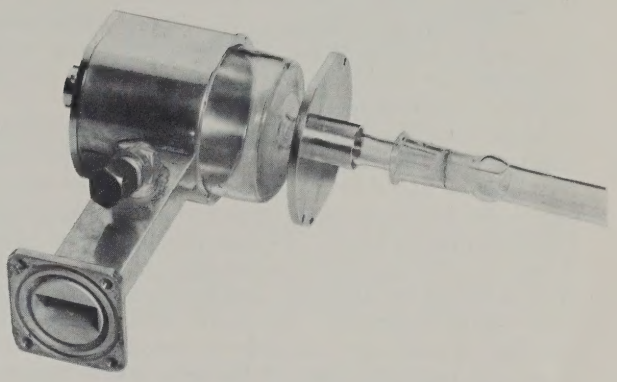
Using paramagnetic resonance techniques, H. E. Radford of the cryogenic physics laboratory is conducting a laboratory investigation, partly sponsored by the Navy, to determine the frequencies by which radicals believed to exist in outer space may be detected. Measurements have been completed on the long-lived OH radical, and the equipment is being modified to permit determination of the spectra of the short-lived radicals CH and SH.

The ground rotational levels of the radicals being studied are split by a Λ-type doubling, with the splitting falling in the low microwave range of frequencies. The Λ-type spectra are of the electric dipole type, having intrinsic intensities several orders of magnitude larger than the magnetic dipole hyperfine spectra, of which the hydrogen 21-cm line is an example. Therefore, concentrations of these hydrides as low as 10^{-6} molecule/cm^3 should be detectable, compared to a limit of 10^{-2} hydrogen atom/cm^3.

OH *Radical Measurements*

As convential microwave spectroscopic techniques are insensitive at the frequencies of the molecular transitions under study, the paramagnetic resonance technique is being used in this investigation. This method involves the application of a strong magnetic field to the material being studied, the field shifting the low-frequency spectra to a high microwave range where measurements can be made with optimum sensitivity.

Measurements were made by passing a high-frequency microwave (9,000 Mc/s) through a waveguide and into a resonant cavity absorption cell (volume about 100 ml) containing the OH radicals. The cell is situated between the poles of a powerful electromagnet, the field strength of which was varied from 0 to 11,000 gauss. A crystal detector monitors the electromagnetic energy coming back out of the cell, and this quantity, after amplification, is recorded on a strip chart as a function of the magnetic field. From the frequency of the radiation beamed into the cell, and the magnetic fields at which absorption peaks occur, the frequencies



Exploded view of absorption cell (2½ in. diam.) used to make paramagnetic absorption measurements on OH radicals. The radicals are pumped through the quartz cell from right to left. Microwaves are beamed into the cavity through the rectangular waveguide at the lower left.

of the molecular transitions are computed. For the OH radical, the frequencies corresponding to the maximum absorptions are 1665.32 and 1667.36 Mc/s. These values agree closely with previously reported data,[1] and can be detected with existing radiotelescopes.

Radical Production

OH radicals were produced outside of the absorption cell by pumping water vapor through an electric discharge and into the cell. This procedure is successful with OH, which has a lifetime of about 1/3 sec at the pressure used in this study, but could not be used for the short-lived CH and SH radicals. Therefore, a technique is being developed that will separate the production and observation of the radicals in time rather than in space.

In the time-separated sequence a radar transmitter will be used to supply a microsecond burst of power to the spectrometer cavity, causing ionization and dissociation of a portion of the gas within the cell. During this period the spectrometer is gated off by a waveguide switch. After a deionization period of about 10^{-5} sec the spectrometer will be gated on and the products examined for microwave resonances. The rate of this sequence will be dictated by the lifetime of the radical under investigation, a typical rate being 1000 c/s.

[1] *G. Ehrenstein, C. H. Townes, and M. J. Stevenson, Phys. Rev. Letters 3, 40 (1959).*

Miniature Helium Expansion Turbine

With Gas-Lubricated Bearings

THE CRYOGENIC Engineering Laboratory of the Bureau's Boulder (Colo.) Laboratories has developed a miniature helium expansion turbine for operation in a helium liquefier or refrigerator. Rubbing friction and bearing wear have been eliminated in this device by replacing conventional rolling-element bearings with gas-lubricated journal and thrust bearings of the externally pressurized type. The life of these bearings should be indefinite, and the speed of the shaft supported by the bearings is limited only by the strength of the material.

In the production of refrigeration at liquid helium temperatures, the use of an expansion turbine eliminates the need for liquid hydrogen precooling of the helium below the inversion point [1] prior to expansion of the helium through a valve. The extra complication introduced by the expander is usually justified by the elimination of the explosion and fire hazard associated with liquid hydrogen. In small refrigerators and liquefiers it has been customary to use a reciprocating expansion engine because of the high speeds required of a turbine expander. These high turbine speeds are beyond the speed and life limits of conventional roller element bearings. However, this limitation does not apply to gas-lubricated bearings. In a properly designed gas bearing the shaft can be maintained in a position of stable equilibrium so that it never touches the surface of the bearing.

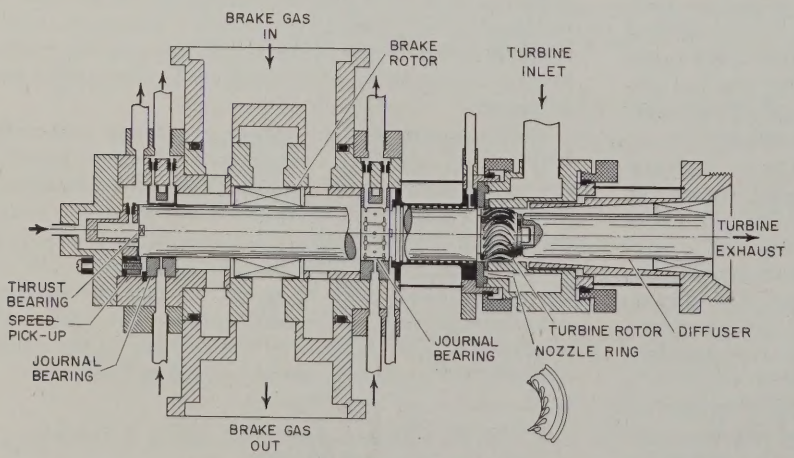
Based on a theoretical analysis by H. Sixsmith and subsequent experimental work by Sixsmith, W. A. Wilson, and B. W. Birmingham,[2] an analytical rather than a cut-and-try approach to the design of the bearings has been developed. The bearings are provided with pneumatic phase-shift networks designed to ensure stability at extreme rotational speeds. During actual tests the shaft has been observed to be in a position of stable equilibrium at an operating speed of 3,000 rps.

The miniature helium expansion turbine developed by the Bureau (below) was designed for a refrigerator cycle having an expander inlet temperature of 17.6 °K and a flow rate of 530 standard cubic feet per minute (SCFM). The inlet pressure is 15 atm and the outlet pressure is 1 atm. The turbine is of the mixed flow type—radial inlet and axial outlet. The rotor passages are of the impulse type, having a very small amount of reaction. The expansion ratio in the nozzle ring is about 10 and in the rotor about 1.6. A recompression ratio of about 1.07 is effected by the diffuser, thus accounting for an over-all expansion ratio of 15. The power generated by the turbine is absorbed by means of a centrifugal blower which acts as a brake. The blower operates in a closed circuit in series with a cooler and a throttle valve.

An exploded view of the main components of the turbine expander is shown on p. 3. A specially designed pantograph was constructed for the purpose of machining the turbine rotor.

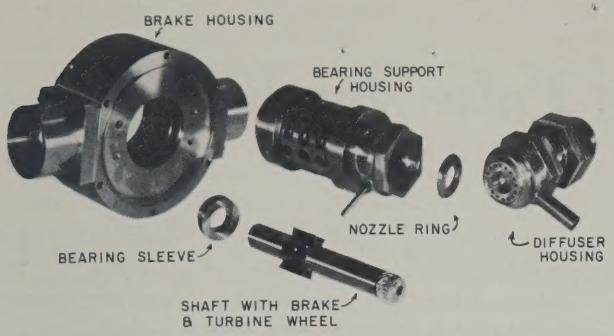
Both the journal and thrust bearing operate at room temperature, the turbine rotor being mounted on an extension of the shaft which overhangs into the cold region. The shaft is made of 410 stainless steel, chosen because of its low thermal conductivity and high tensile strength. The diameter of the shaft is the same as that of the turbine rotor—7/8 in.; thus, the need for a heavily loaded thrust bearing is eliminated. The rotor design is unconventional, but fabrication is simple and problems arising from axial misalinement are minimized. The turbine was designed with simplicity of construction in view, so that, if required, much smaller turbines could be constructed along the same lines.

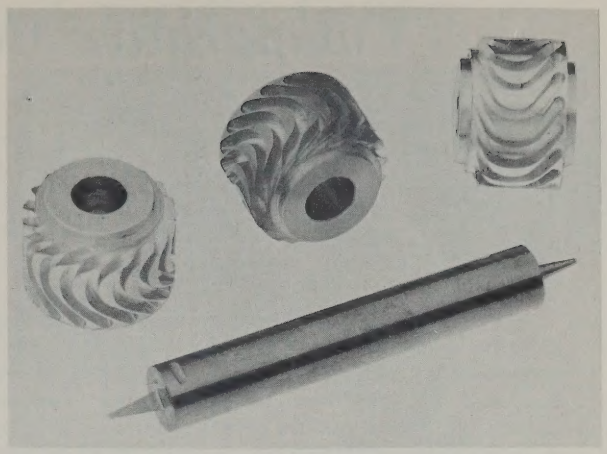
The turbine expander was tested over a wide range of conditions to determine its operating characteristics and to test the stability of the bearings. It is estimated that the turbine efficiency at design conditions should approach 60 percent. At a total flow rate to the turbine and gas-lubricated bearings of 180 SCFM, the journal bearings were found to absorb a flow of 37 SCFM, or 21.3 percent. As the bearings will operate warm in a



Miniature helium expansion turbine. Helium to be cooled enters the turbine at 15 atm and exits at 1 atm. Helium gas supplied at 15–20 atm lubricates the journal and thrust bearings, preventing metal contact at shaft speeds up to 3,000 rps.

Below, **Close-up view of several rotors and the machine tool used in their formation.** *Right,* **Exploded view of the main components of the miniature turbine.**





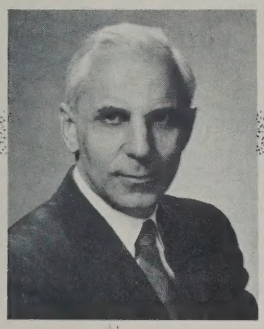
low-temperature installation and the total flow is estimated to be 530 SCFM, this gas flow to the bearings represents about 6.5 percent of the total flow. The gas-lubricated bearings were found to be stable and functioned properly at bearing supply pressures from 10 to 20 atms.

The design of this turbine expander has proved to be satisfactory. The experimental tests showed that the gas-lubricated bearings are stable with the turbine operating at room temperature when producing up to 7 kw of refrigeration. As the design load is approximately 3 kw, the bearings should possess more than adequate stability under normal operating conditions. They should operate indefinitely when proper precautions are taken to provide clean supply gas. Such a design is quite adaptable to the application of a liquefaction or refrigeration cycle for trouble-free operation. The size of an expander such as this is limited only by practical fabrication techniques, which makes it adaptable to very small liquefaction or refrigeration cycles.

---

[1] *The inversion temperature is that temperature, characteristic of a particular gas, at or below which the gas will cool upon expansion.*

[2] Load carrying capacity of gas-lubricated bearings with inherent orifice compensation using nitrogen and helium gas, *by H. Sixsmith, W. A. Wilson, and B. W. Birmingham. NBS Tech. Note 115, available from Office of Tech. Services, Department of Commerce, Washington 25, D.C. ($1.00).*



Special International Program Established

Alt Named Coordinator

THE BUREAU has received an appropriation of $1,000,000 of U.S.-owned foreign currencies to be used for scientific research in foreign countries. Dr. Franz L. Alt, Coordinator of Special International Programs, will handle the establishment and operation of the projects.

This is the first time the Bureau has received an appropriation from the foreign currency funds which have accumulated from the sale of U.S. surplus agricultural products to foreign governments.

The research programs will be undertaken in India, Pakistan, and Israel and will include projects which complement and supplement the research programs undertaken in the Bureau's laboratories. In establishing the program, Dr. Alt will work through the State Department, U.S. Embassies, and the governments of the countries involved.

Dr. Alt, who has specialized in computing machines and numerical methods, has been at the Bureau since 1948. As Assistant Chief of the Applied Mathematics Division, he has worked with computing machines and their application to military tactical problems, mathematical methods in management, pattern recognition, and machine translation of languages.

Before joining the Bureau staff, Dr. Alt did research work at the Ballistic Research Laboratories, Aberdeen Proving Grounds, in Maryland, and the Econometric Institute in New York City. A native of Vienna, Austria, Dr. Alt received his Ph.D. in mathematics from the University of Vienna in 1932.

Dr. Alt has been President and Chairman of the Editorial Board of the Association for Computing Machinery.

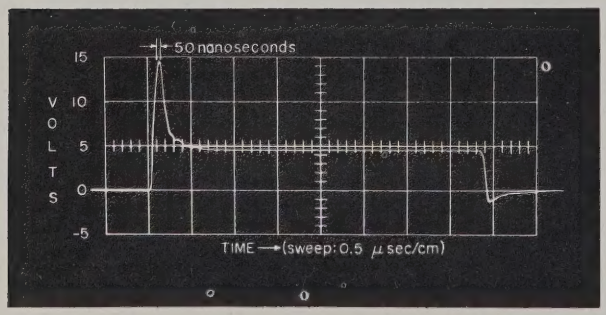
Comparative Measurement of Pulse Amplitude

A PULSE AMPLITUDE comparator which evaluates the peak amplitude of pulses as narrow as 50 nanoseconds (0.05 μsec) has been developed by Owen B. Laug of the Bureau's engineering electronics laboratory. This circuit, which compares the peak voltages of an input waveform with adjustable upper and lower limits, is one of the circuits comprising a module evaluator being designed for the Navy Bureau of Ships.

The pulse amplitude comparator circuit should find application wherever it is desired to detect the presence of repetitive or nonrepetitive pulses exceeding preset positive and negative limits. The circuit reported in this article is particularly useful for sensing the presence of nonperiodic transient voltages exceeding a set limit, such as voltage surges on signal or power lines. This circuit can either supply visual indications or operate a counter or circuit-protection relay.

The comparator circuit is entirely transistorized. It consists of a pair of coupled blocking oscillators which trigger a monostable switching circuit to operate a relay. The two blocking oscillator stages are identical except for the type of transistor used—one being a pnp-type and the other an npn-type—and the different power input polarity required for each. The two transistors of this stage are regeneratively coupled so that both are triggered into the conduction cycle when either is triggered by a voltage (positive for one, negative for the other) exceeding its reference level. The reference levels are individually adjustable from 0.5 to 1.0 volt direct current (VDC).

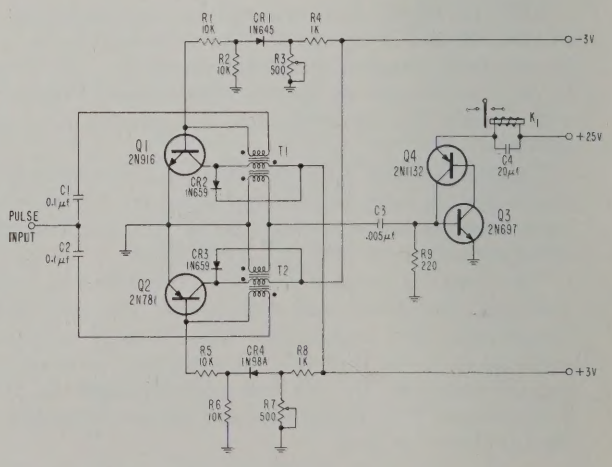
Sample waveform having a peak amplitude which the pulse amplitude comparator is useful in evaluating. Note the 50-nanosecond pulse-width. Waveform must be reduced by a voltage divider so that the desired GO, NO-GO boundary lies within the sensing range of the circuit.



The blocking oscillator output from the paralleled transformer tertiary windings triggers the two transistors of the switching circuit. These are connected to provide a feedback path that will drive both into saturation when the circuit is activated. This action energizes the switching relay, the coil of which is in the power input line to this stage. The time constant associated with the relay coil was chosen, in the circuit constructed, to keep the relay energized for the period between periodically recurring pulses. The relay remains closed as long as a pulse great enough to trigger the circuit occurs at each anticipated repetition time, but this is only one of the possibilities of this circuit.

The circuit constructed for this application uses bias voltages of +3 and −3 VDC, in addition to the supply voltage of 25 VDC. The input circuit must be designed to match the circuit threshold capabilities to the desired input boundaries, in order to permit circuit triggering at the levels desired. The bias potentiometers for the positive and negative sides can be set for the precise GO, NO-GO boundaries desired.

Transistorized pulse voltage comparator. Transistors Q_1 and Q_2 are of complementary types (Q_1 is npn, Q_2 pnp), which enables the circuit to be triggered by either a positive or negative over-reference-level signal. Q_3 and Q_4 are regeneratively coupled to go into saturation and energize K_1 immediately upon receipt of the blocking oscillator pulse from Q_1—Q_2.



Radio Refractive Index Data Center

THE BUREAU has established a Radio Refractive Index Data Center at its Boulder (Colo.) Laboratories to assist in studying radio propagation in the earth's atmosphere. The data collected at this Center on the variable refraction of radio waves at given times, heights, and places are correlated and made available to scientific, Government, and industrial groups. The ready accessibility of such information from a central source simplifies the computations required, for example, in evaluating missile tracking and guidance systems, in establishing error correction for height-finding radars, in predicting transmission loss for tropospheric communication links, and in estimating radio wave field strengths for many types of radio propagation.

The bending or refraction of radio waves in air is a function of atmospheric pressure, temperature, and relative humidity which varies in a systematic fashion with climate.[1] These meteorological parameters, obtained from weather radiosonde observations and from special airborne instruments which record changing refractive index structures above the earth, are forwarded periodically to the Boulder Laboratories. At present, such data are being received from over 300 stations located in the continental United States and in South Africa, Antarctica, Saudi Arabia, the Canal Zone, Cyprus, Germany, Greenland, Hawaii, Japan, Korea, Morocco, Newfoundland, Tripoli, and from weather ships stationed in the Atlantic and Pacific Oceans.

Data thus far catalogued and referenced are recorded on more than 7,000,000 punched cards. Appropriate sets of these cards provide the necessary information for computer calculations of radio refractivity in specified areas around the earth. The Radio Refractive Index Data Center is equipped to correlate the data for certain areas, and to establish radio refractive index profiles for those areas, indicating seasonal variations.[2] However, if individual agencies prefer to make their own calculations, these cards may be made available for their use. Also, an analysis has been published [3] of radio refractive index data including both tabulations of basic data for specific locations and charts for interpolation to any location. The present goal of the Center is to collect sufficient data to survey and plot radio refractive index profiles for the atmosphere of the entire earth.

Part of the 7,000,000 punched cards maintained by the Radio Refractive Index Data Center.

[1] *For information on radio refractometry, see* Radio refractometry, *NBS Tech. Note 66, by Jack W. Herbstreit (1960), available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. ($.50).*

[2] *Further details of this service may be obtained from the Radio Meteorology Section, National Bureau of Standards, Boulder, Colo.*

[3] *NBS Mono. 22,* Climatic charts and data of the radio refractive index for the United States and the world (1960), *available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. ($2.00).*

1961 Technical Session on Bone Char Research

Progress in the technology of carbon adsorbents, including bone char, was the principal topic of the Seventh Technical Session on Bone Char Research [1] held at the Bureau on October 5 and 6, 1961. Sponsored jointly by the Bureau and the Bone Char Research Project, Inc., the Session was devoted mainly to research papers on the adsorbent problem in sugar refining, including char regeneration and the mechanism of the bone char process.

The biennial meetings were initiated to compare and exchange data on adsorbents for purifying commercial sucrose solutions and to inform the sugar industry of the progress of bone char research. Highlighting this Session were fundamental papers on the mechanism of solution-adsorbent processes and technical papers on completely automatic absorbent-systems, using either fixed absorbent beds or an expanded counter-current adsorbent process. In all, 15 tech-

621939—62——2

nical papers were presented. The Program Chairman of the Session was V. R. Deitz of the Bureau staff.

Bone char is the residual product of pyrolysis of animal bones. Granules of this material are remarkably similar—both in shape and structure—to cracked bones, and are very porous. It is this porosity, and the resulting large surface area of the char, that are mainly responsible for its purifying properties. Because of the enormous quantities of bone char required—approximately 2 million tons are used annually in the United States alone—the economic success of sugar purification depends largely on the efficiency with which the char can be regenerated for repeated use. Until recently, the sugar-refining industry used bone char almost exclusively. Today, however, other synthetic granular carbon adsorbents, prepared from domestic sources, are also available.

In an attempt to understand the fundamental nature of bone char and other solid adsorbents in sugar purification, a research program sponsored by the Bone Char Research Project, Inc., was initiated at the Bureau in 1939. There are now 28 industrial supporters of this program, including cane sugar refiners and manufacturers of refining adsorbents in Australia, Belgium, Brazil, Canada, England, France, Holland, Scotland, and South Africa, as well as the United States.

The Technical Session opened with a welcoming address by Dr. Edward Wichers, Associate Director of the Bureau. The first four papers of the Session concerned impurities found in raw and refined sugar. Nonsucrose constituents are essential to the metabolic growth of sugar cane. As in all natural products, these constituents may vary extensively. L. F. Martin of the Department of Agriculture reported that some complex organic nonsugars completely escape the entire refining process. This finding was confirmed in the paper given by A. M. Hertzberg, E. W. P. Cunneen, and D. C. Bills of Colonial Sugar Refining Company, Ltd. (Sydney, Australia), who found that nonsugars remaining after phosphatation and flotation are mainly organic matter of plant origin.

A survey of many of the impurities in sugar was presented by W. L. Reed and J. V. Congdon of the Revere Sugar Refinery. By methods developed at the Bureau, sugar samples from every state of the refining process were analyzed. From these analyses, changes in concentration of each impurity caused by addition or removal of materials as well as chemical changes due to processing, heat, *p*H, and other factors were determined. This research indicates the efficiency of each step involved in purification.

Decolorization of the sugar in process is one of bone char's chief functions. D. Larry [2] and F. G. Carpenter [2] showed that this color removal is largely dependent upon the nature and quantity of other organic and inorganic ions present. A new process parameter, the "excess polyvalent anions" (EPA), was proposed as the explanation for the interaction of adsorbable polyvalent anions on bone char's removal of colorant bodies. C. W. Beal and N. L. Pennington of the California and Hawaiian Sugar Refining Corp. demonstrated that the decolorization process can be improved by a tight prefiltration just prior to bone char treatment. These results indicate that naturally occurring colloidally suspended substances have a marked influence on color removal.

Having studied the expanded-bed counter-current continuous adsorption process (CAP), W. Marcy of the American Sugar Refining Co. described the current operation of color removal realized with this completely automated process. B. W. Drean of Tate and Lyle, Ltd. (London) discussed the hydraulic handling of bone char by water displacement through 3-in. pipes. This method has proven to be very successful in the Thames Char House in London. Both the CAP and hydraulic handling process are directed toward fully automated operation with granular adsorbents, a goal of sugar refining for many years.

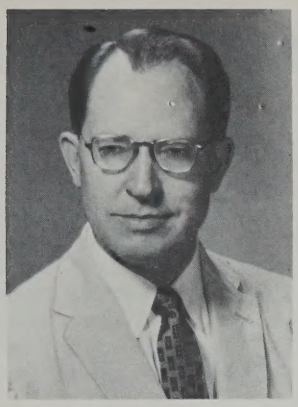
Several aspects of bone char revivification were presented. It is well known that freshly kilned char will undergo a rapid *p*H drop when exposed to ambient atmospheres. John Redd, VI,[2] disclosed that this deterioration is caused by specific interaction with carbon dioxide. Amplifying on spent and regenerated char were E. P. Barrett of Baugh Chemical Co., who spoke about the detrimental effect of too low or too high kiln temperature on subsequent decolorization, and H. M. Rootare,[2] who described the desorption mechanism of calcium sulfate in aqueous suspensions of revivified bone char. Spent char with freshly adsorbed impurities undergoes a low-temperature reaction with oxygen, reported F. G. Carpenter.[2] Enough carbon dioxide will then be produced to lower the *p*H. This can be avoided by low-temperature air-oxidation immediately after the drying of the char, followed by a high-temperature treatment at 550 °C.

The state of synthetic adsorbents was also discussed. F. W. Schwer, National Sugar Refining Co., considered improving low-grade service char with Synthad; and A. M. Bartolo, Imperial Sugar Co., outlined continuous pipeline defecation with kieselguhr. L. F. Gleysteen of Atlas Chemical Industries, Inc. presented a paper on the hardness of new granular Darco, and T. A. Wilson, J. P. Treumper, and J. A. Fayard of the same company described industrial plant-scale operations using granular Darco.

---

[1] *The Proceedings will be published in the near future.*

[2] *Bone Char Project Research Associate at the Bureau.*



Wildhack Named Associate Director

William A. Wildhack has been appointed an NBS Associate Director. He will be responsible for coordination of NBS measurement services to science, industry, other agencies of the Federal government, and the States. These services include consultation and research on special problems of measurement, and calibrations and tests performed on instruments, equipment, and materials, and the distribution of standard samples and reference materials.

Since 1960, Mr. Wildhack has been Special Assistant to the Director, exploring the needs of industry and other Government agencies for precision standards, calibration services, and improved measurement techniques.

Mr. Wildhack, who received a B.S. in electrical engineering in 1931 and an M.S. in physics in 1932 from the University of Colorado, taught physics and mathematics at that University, at Boise Junior College, and later at George Washington University.

In 1935, Mr. Wildhack came to the Bureau as a physicist in the Aeronautical Instruments Section. As Chief of the Missile Instrumentation Section, 1948–1950, he was responsible for the direction of flight tests of guided missiles and the development of equipment for evaluating their performance.

From 1950 to 1960, Mr. Wildhack was Chief of the Office of Basic Instrumentation. In this position, he directed a large number of successful research and development projects in measurement and calibration.

Mr. Wildhack pioneered the practical development of the "Peek-a-Boo" retrieval system, and its use in the instrumentation reference center, which now has a collection of over 25,000 references.

In addition to articles related to instrumentation, his publications and patents range from nuclear energy to parachuting to satellite orbits and aircraft oxygen equipment.

In 1958 and 1959, he and Dr. R. D. Huntoon, NBS Deputy Director, worked with the staff of the House of Representatives Appropriations Committee. With the help of a group of eminent scientists, they studied reliability efforts in the major missile program and evaluated the Vanguard Satellite Program.

Mr. Wildhack received the silver medal of the Royal Swedish Academy of Engineering Sciences in 1949. He served as President of the Instrument Society of America in 1954, and in 1959 was named the first Fellow of that Society.

Dr. Charles M. Herzfeld, recently appointed an Associate Director, has joined the staff of the Advanced Research Projects Agency to serve as Assistant Director. In response to an urgent request from the Defense Department, the Bureau has agreed to the transfer of Dr. Herzfeld for one year to direct a program of great national importance—research on defense against ballistic missile attack. His recent experience with various groups studying the U.S. missile effort makes him well qualified to handle such an important mission in this field.

1962 NBS Course in Radio Propagation

The 1962 National Bureau of Standards course in Radio Propagation will be given July 16 through August 3. The course, administered by the NBS Boulder, Colo., Laboratories, is open to scientific and engineering personnel in other government agencies, industry, or universities.

There were 235 participants in the 1961 Radio Propagation course, representing almost every state in the Union and several foreign countries. The course is being repeated in 1962 in response to requests from many individuals who were unable to attend in 1961.

Full particulars concerning the 1962 curriculum and information concerning registration will be published in the near future by the Boulder Laboratories' Graduate School, which is directed by E. H. Brown, consultant in mathematical physics.

An Improved Resistanc

Continuing work at the Bureau to increase the accuracy of temperature measurements has resulted in a redesigned version of the Mueller resistance thermometer bridge. The modified bridge has improved stability and extends measurement accuracy by a factor of 10, presenting dial indications in steps of 1 μohm. Specifications for this bridge were developed by J. P. Evans of the temperature physics laboratory.[1] The Leeds and Northrup Co. developed the mechanical design and fabricated the instrument.

Temperature Measurements

Resistance thermometers have been useful in making precise temperature measurements since the late 19th century. A resistance thermometer consists of a sensing element which changes in electrical resistance in response to changes in its temperature. In precision thermometry the temperature is computed from the resistance measured by connecting the thermometer as one arm of an accurate resistance bridge. A coil of platinum wire is commonly used as the thermometer winding; its temperature can be computed by use of a formula which relates its resistance at any temperature to its resistance at 0 °C,[2] with minor variations among samples of platinum.

The platinum resistance coils used in resistance thermometry have nominal resistances of 0.25 to 100 ohms at 0 °C. The resistance changes in the lower-resistance thermometers are so small that lead resistance and contact resistance would reduce accuracy alarmingly if not balanced out or nearly eliminated. For this reason special measurement techniques have become common in this field. Inaccuracy due to resistance in the thermometer leads is minimized by connecting the battery or galvanometer directly to one end of the resistance coil so that the resistances of the two other leads are in different bridge arms. The resistance is then computed as the average of two bridge balances, the second taken with the thermometer leads reversed. A fourth resistor lead is required as the battery lead to keep the resistance winding in the "X" arm of the bridge when the resistor and leads are reversed.

Precautions to minimize variations in resistance across switch contacts have taken several forms. Wiping action of the switch blades or links on the contacts rubs off surface film and burnishes the mating elements. Electrical contact in other switches is improved by the metallic wetting qualities of an excess of mercury on the mercury amalgam of the contacting surfaces.

Resistance Bridges

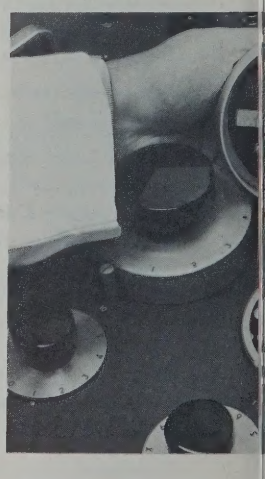
A Wheatstone bridge modification devised by E. F. Mueller at the Bureau in 1916 [3] has been used extensively in precision thermometry. Mueller later redesigned his bridge [4] to provide additional checks on its accuracy and stability. The bridge has a one-to-one ratio—the resistances of arm A and arm B are equal and fixed (except for a small adjustment). At balance the total resistance of the incremental resistors of arm R is equal to that of X, the thermometer. This configuration made possible several checks on instrument balance prior to making measurements, such as comparing arms A and B for equality by transposing them in the circuit and equalizing them by adjusting a slide-wire resistor. In making measurements the thermometer lead resistance can be balanced out by averaging measurements before and after lead reversal.

Modified Mueller Bridge

In the present version of the Mueller bridge, advances in the arts involved in instrument construction have made possible several modifications and some new features. The addition of a lower resistance decade has increased maximum measurement definition to 1 μohm. The instrument's range is 0 to 422 ohms.

Mercury-wetted contacts, slightly different from those of the preceding modification of the Mueller bridge, are used for the 0.01-, 0.1-, 1-, 10-, and 100-ohm switches. These are radial switches, composed of an upward-projecting stud for each switch position, a central ring contact, a spring-loaded contacting link mounted inside a rotatable switch cap, and a detent mechanism. Each of these switches opens a current-interrupting switch in the battery circuit to safeguard the galvanometer while the switch is being operated from one position to the next. The mercury amalgam surfaces require little maintenance, but the excess mercury is drawn off and replaced with clean mercury at intervals.

The four lower resistor decades in the modified bridge—0.001 ohm, 100 μohm, 10 μohm, and 1 μohm—are switched by means of sets of enclosed wafer switches having brush-type contacts. The decades are Waidner-Wolff elements, like those used in preceding Mueller bridges, in which the switched resistors are of higher value than a fixed shunt resistor. The contact resistance is placed in series with a relatively high-value,



Thermometer Bridge

and paralleled by a relatively low-value, fixed shunt resistor, reducing the effect of variation in contact resistance. Variation in contact resistance is further minimized by paralleling two switch wafers for each decade, permitting it to be disregarded without introducing significant error. It is felt that this type of switch represents an improvement over those used in previous Mueller bridges.

Both the new bridge and the preceding Mueller bridge use a commutating switch to reverse ratio-arm connections and the resistance-thermometer connections simultaneously. The new bridge includes a 10-turn adjustable resistor shunted by a low-value fixed resistor in place of the former slide-wire divider between arm *A* and arm *B*. It makes possible adjustment of the arm *A*–arm *B* ratio within a range of 0.04 percent of unity.

In practice the adjustable resistor and the bridge switches are adjusted to obtain a null that is displaced only slightly when the ratio arm and thermometer lead positions are reversed. At this adjustable resistor setting the average of the two values measured (at normal and reversed positions) is virtually unaffected by ratio arm unbalance. Errors due to thermometer lead resistance offset each other and vanish also in the averaged measurement.

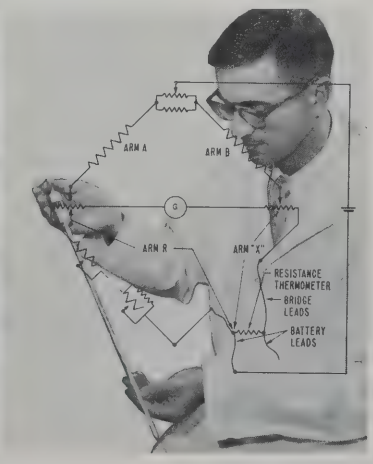
Internal Temperature Control

The order of accuracy required of this instrument can be obtained only by closely controlling the temperature of its critical resistors. The temperature stability of 43 of the resistance coils is enhanced by mounting them within holes drilled in an aluminum block heat reservoir. The block is enclosed in, but thermally insulated from, an aluminum box having slots in the side for manganin connecting links to the resistance coils. The manganin alloy chosen for the coils has its smallest coefficient of resistance at about 35 °C. Since it is anticipated that a bridge will be used in rooms maintained at about 25 °C, both the preceding Mueller bridge and the new one maintain critical bridge resistors at 35 °C for maximum stability, while introducing only a nominal amount of heat into the bridge.

The temperature of the aluminum box, and hence of the block within, is maintained at 35 °C, by means of heating coils wound around the box in a noninductive and evenly distributed pattern. Power to the heaters is controlled by a transistor switch located in an accessory equipment box and a mercury-in-glass thermoregulator mounted in a wall of the aluminum box. With the thermoregulator set at 35 °C and the coils powered by 6 volts direct current (VDC), the heater is on about 50 percent of the time in ambients of 25 °C. A similarly mounted bimetallic thermostat set to open above 40 °C is connected in series with the heater as a safety measure. The whole assembly is thermally insulated by being enclosed in a balsa wood layer. A bent-stem thermometer is mounted with its scale flat on the instrument's panel and its bulb projecting down through a hole into the thermostatically controlled enclosure to indicate the temperature there.

New Techniques

Other modifications of the Mueller bridge are in response to new techniques, rather than to refine the original equipment. One such change is the inclusion of an additional switch section on each resistor-selector shaft for operation of external digital data-recording equipment. This auxiliary switch is insulated from the measuring circuit and its shaft is



Left, **J. P. Evans makes a precise temperature measurement, using a platinum-wire resistance thermometer (protruding from top of calibration furnace in background) and a resistance bridge (foreground). Ground glass scale mounted in foreground is for reading indication reflected from galvanometer. The small box to the left of the furnace contains bridge internal temperature control circuitry. The temperature is computed from the measured resistance of the platinum winding, which increases with rising temperature. The bridge is a recent modification of the Mueller bridge, first developed for this purpose at NBS in 1916.** *Center,* **Mercury-wetted contacts are used for switching resistance decades in the Mueller bridge. Rotating link inside switch cap, raised, bridges ring contact and selected stud. All conducting parts are copper with contact surfaces amalgamated with mercury, a surplus of mercury being retained to keep contact resistance low and unvarying. The mercury is drawn off and replaced with clean mercury periodically.** *Right,* **The modified Mueller resistance thermometer bridge introduces features to facilitate making accurate measurements with a minimum of computation. Characteristics of Mueller bridges include equal ratio arms, galvanometer connected to ends of decades in R and X arms, and 4-terminal resistance thermometer. Characteristics of modified bridge include parallel-connected enclosed wafer switches for Waidner-Wolff decades, and simultaneous reversal by commutating switch of ratio arms, bridge-thermometer leads, and battery-thermometer leads.** *Background,* **Evans holds a platinum-wire resistance thermometer.**

grounded. The lead-assignment scheme permits external equipment to sense all resistor selections by scanning continuity conditions among 25 leads brought out of the bridge.

The modified bridge, like previous forms of the Mueller bridge, is balanced by means of indications on an external galvanometer. The measuring circuits of the new bridge are carefully shielded to permit the use of sensitive electronic null-detection devices, if desired. The bridge is housed in a metal case, the digital read-out switch sections are separate and guarded from the measurement circuitry, knobs and shafts make electrical contact with the case, and switch parts and binding posts are insulated from the panel. Grounding leads for the bridge case, the temperature-stabilizing box, and the auxiliary read-out circuit guard are brought out to the panel at three separate, insulated binding posts.

[1] *John P. Evans,* An improved resistance thermometer bridge, *to appear in Temperature, its measurement and control in science and industry, Vol. 3 (Reinhold Publ. Corp., New York, N.Y.).*

[2] *Forest K. Harris,* Electrical Measurements (*Wiley, 1952*), *page 290.*

[3] *E. F. Mueller,* Precision resistance thermometry, *Temperature, its measurement and control in science and industry, Vol. 1 (Reinhold Publ. Corp., New York, N.Y., 1941), page 162.*

[4] *H. F. Stimson,* Precision resistance thermometry, *Temperature, its measurement and control in science and industry, Vol. 2 (Reinhold Publ. Corp., New York, N.Y. 1955), page 141.*

Certification of Haemocytometer Cover Glasses Discontinued

THE BUREAU has discontinued the certification of haemocytometer cover glasses as of January 1, 1962. It will continue to calibrate the haemocytometer chambers themselves, and this service includes the certification of two cover glasses for each chamber. In addition, referee testing will be provided to determine the reliability of cover glass tests carried out in commercial or university laboratories.

From time to time the Bureau reviews the services it renders to other Government agencies and to the public to determine the continuing need for these services and their availability from other laboratories. This action is in keeping with a longstanding Bureau policy of withdrawing from activities that may be carried on by private industry so that more Bureau resources may be directed toward the development of new standards and calibration services.

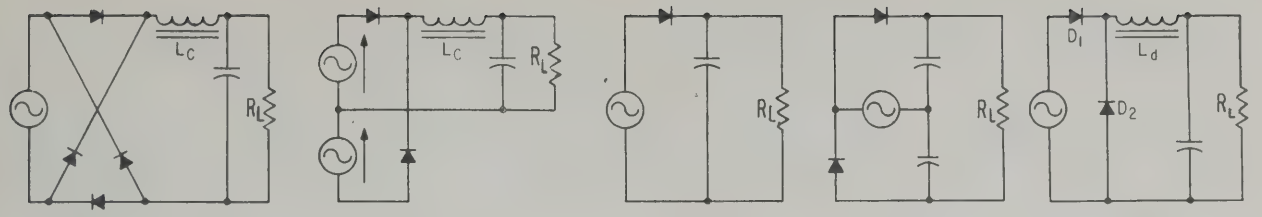
The history of haemocytometer cover glass testing at NBS extends back to World War I. At that time inaccurate blood count determinations were traced to the lack of precision in the haemocytometer chambers in use and the lack of planeness in the cover glasses available. The Bureau was therefore requested to test these devices to assure proper blood count determinations. Specifications were established for their manufacture in which the required degree of planeness for cover glasses was stipulated.

In the intervening years the Bureau has served as a central testing facility to assure that both the chambers and the cover glasses measured up to specifications. However, because of the increasing accuracies continually being achieved in glass manufacturing techniques during this time, fewer and fewer cover glasses are failing to meet specification requirements. In addition, relatively simple interferometric equipment—all that is required to measure the degree of planeness in a surface—is now available and easily used in most optical laboratories. Hence, the decision was made by NBS to discontinue routine testing in this area.

Improved Rectifier Circuits

ELECTRICAL POWER rectifier circuits developed by G. Franklin Montgomery of the Bureau will provide improved regulation and filtering in certain single-phase rectifiers. The improvement is desirable for the great majority of equipments using power rectifiers, especially in the field of electronic instrumentation where good regulation and ripple-free outputs are required. These circuits are derived from conventional circuits; three of them require a component that is a modification of a conventional component.

Power rectifier circuits, used in virtually every electronic equipment, take the form of a full-wave bridge (fig. 1), a full-wave half-bridge with center-tapped source (fig. 2), a half-wave rectifier (fig. 3), or a voltage multiplier, such as the voltage doubler (fig. 4). Power supplies include rectifiers and a filter which is of either the capacitor-input or inductor-input type. Half-wave rectifier and voltage-doubler circuits using capacitor input (popular because of their low cost) are characterized by particularly poor filtering and regulation. Attempts to improve such circuits by adding an inductive filter usually result in reduction of both maximum output current and output voltage. The conductive portion of the cycle is lengthened, but rectifier current nonetheless falls to zero for part of the cycle, and alternating current is not eliminated from the output. The circuits devised at NBS are intended to improve filtering in half-wave rectifier and voltage-multiplier circuits.



1 2 3 4 5

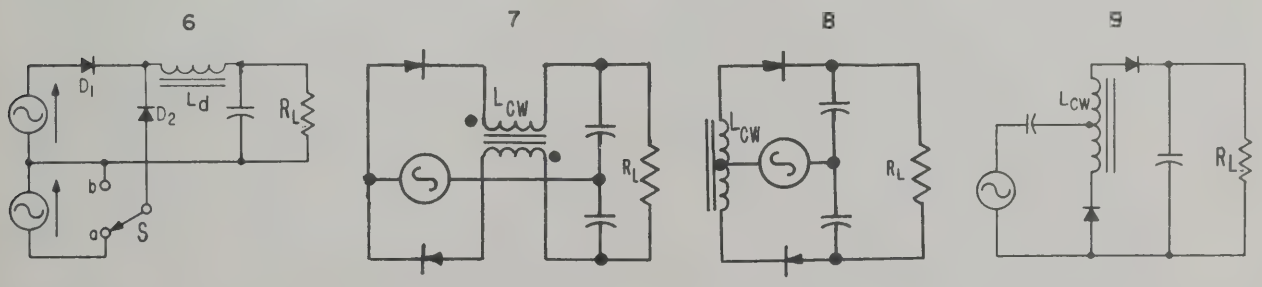
Ripple—an alternating current superimposed on the direct-current output of a rectifier—is present in the conventional half-wave rectifier output because half-wave rectification produces current only during every other half-cycle. Current through a series inductor would have to fall to zero during at least part of alternate half-cycles—hence ripple. The new circuit shown as figure 5 has an added diode, D_2, to provide an alternate path for the inductor current. During otherwise zero-current half-cycles the inductor can draw current through D_2 to obtain improved filtering for the same component and load values. Current will be continuous if the inductance is greater than a calculated minimum, called the critical inductance. The critical value in henries (h), a function of R_L (load resistance in ohms) and f (frequency in cycles per second), is $L_c = 0.05263\ R_L/f$, which becomes $L_c = R_L/218$ h for a 60-c/s power line frequency. This circuit has a d-c voltage output that is 0.45 times the root mean square (rms) input voltage. A further modification of this circuit, shown in figure 6, makes it possible to convert the half-wave rectifier to the full-wave, half-bridge circuit shown in figure 2 by operating a switch, resulting in doubled voltage output. Components for both of these circuits are commercially available.

Improved circuits for voltage doublers take three forms, shown as figures 7, 8, and 9. None of these circuits places an inductor in series with the entire circuit output, as in the conventional configuration, although another inductor might be included as part of a supplementary filtering network. Instead, the circuit shown in figure 4 is changed by the addition in figure 7 of a dual inductor having electrically separate but magnetically coupled equal primary and secondary windings. The use of such an inductor permits the current to be commutated between the two windings and the magnetic field in its core to be maintained through both half-cycles. If the inductance is greater than the critical value each rectifier will conduct twice the load current for a half-cycle. The critical value for each winding is $L_{cw} = R_L/4560$ h for 60 c/s. Both rectifiers will be cut off simultaneously for part of the cycle if a smaller value is used.

The circuit shown in figure 8 is derived from that of figure 4 by the addition of the center-tapped inductor, a special case of the inductor used in figure 7. Each rectifier and each half of the winding will carry twice the load current for its half-cycle if the half-winding inductance exceeds the critical value L_{cw}.

The voltage doubler circuit shown in figure 9 is a variation of that of figure 8; the critical inductance is the same as for the circuits of figures 7 and 8. All three of these voltage-doubler circuits have a d-c voltage output that is 1.8 times the rms input voltage, neglecting voltage drops in the rectifiers and inductor. For this reason the voltage-doubler circuits are useful for obtaining 200 volts direct current (VDC) output directly from a 117-volt alternating current (VAC) line, without the use of a transformer.

(*1*) Full-wave bridge. (*2*) Full-wave half-bridge. (*3*) Half-wave rectifier. (*4*) Voltage doubler. (*5*) Improved half-wave rectifier circuit. Addition of diode D_2 provides path for current during normally nonconducting half-cycles, permitting continuous current through filter inductor. (*6*) Modification of improved half-wave rectifier circuit. Diode D_2 provides current by-pass to enable inductance to draw current continuously. Switch *S* permits selection of desired output voltage. If immediate power source is transformer secondary, switch makes tap selection. (*7*) Improved voltage doubler uses inductor with two similar windings. Current in alternate windings maintains a continuous inductor field. (Dots show inductor winding terminals having like polarities.) (*8*) Improved voltage doubler uses an inductor with a center-tapped winding. A continuous field in inductor is made possible by half-cycle conduction in alternate halves of winding; inductance exceeding "critical inductance" can maintain current in each half of the inductor for a full half-cycle. (*9*) Improved voltage doubler circuit uses center-tapped inductor. Circuit is variation of rectifier shown in (*8*).



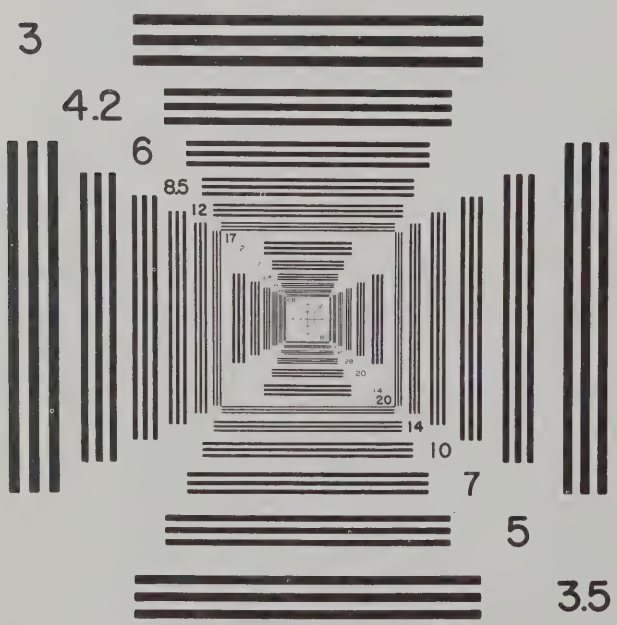
Evaluation of Contrast In Test Charts

THE BUREAU recently evaluated the effects of contrast in the test charts used to determine the image quality of airplane camera lenses. The results show that the position of the plane of best average definition is not significantly affected either by reversal of contrast in low-contrast charts, nor by change from high- to low-contrast charts. However, the values of lens resolving power obtained with high-contrast charts are approximately 50 percent greater than are those obtained with low-contrast charts.[1] These findings are expected to be of considerable aid in interlaboratory comparisons of lens calibrations.

In specifications dealing with airplane mapping cameras, much emphasis is placed on photographic resolving power from which the plane of best average definition in the camera lens is derived. The method of measurement, the test conditions, and the manner of reporting results are usually described in careful terms. However, because lens calibration laboratories employ various types of test charts to measure resolving power, it has been difficult to reconcile apparent differences in intercomparisons of test results. To facilitate these intercomparisons, F. E. Washer and W. P. Tayman of the Bureau's refractometry laboratory undertook the present investigation.

Three types of charts representative of those generally used were selected for the study. The first, based on the NBS chart of 1952,[2] was a long-line, high-contrast chart with black lines on a white background. The second, with identical patterns, was much lower in contrast, having dark grey lines on a light grey background. The third chart was like the second except that the contrast was reversed, with light grey lines appearing on a darker background.

Long-line test chart used, with variations in contrast, for measuring resolving power of lenses.



Precision lens-testing equipment [3] was used to obtain the negatives from which the values of resolving power could be readily determined. In this apparatus, a viewing microscope, a photographic plate holder, and a lens holder are mounted in sequence along an optical bench opposite a horizontal array of 10 collimators (numbered from 1 to 10) spaced at 5-deg intervals from zero to 45 deg. In conducting the tests, 5 high-contrast charts were used in the odd-numbered collimators and 5 low-contrast charts of one pattern in the even-numbered collimators. Thus the imagery of the lens under test could be photographed on a single plate for two types of charts in the same series of focal planes.

Four wide-angle lenses typical of those employed in aerial mapping were used in the study. To obtain a test negative, one of the lenses was alined on the bench so that its optical axis was parallel to and coincident with the axis of the collimated beam emergent from the first collimator. The plate holder was then adjusted until the plane of best visual focus was found. From this position the plate holder was moved forward to a plane 1.05 mm inside the position of best visual focus, and one horizontal row of the charts in the odd-numbered collimators was registered. The plate holder was then moved backward in steps 0.15 mm apart, and downward to avoid superposition, until 15 exposures had been made. Thus the central row was registered at the plane of best visual focus, and the final row at a position 1.05 mm outside best visual focus.

The plate was then displaced sidewise in its holder approximately 12 mm, and the entire bench was rotated 5 deg on its pivot to bring the axis of the lens parallel to and coincident with the axis of the collimated beam emergent from the second collimator. The same procedure was repeated to register the first set of low-contrast charts in the even-numbered collimators. From the resulting negative, values of resolving power for both sets of charts could be determined.

Five charts of the second low-contrast pattern were then substituted for the first low-contrast pattern in the even-numbered collimators and a second negative was similarly obtained. Negatives made for the 4 lenses in this manner were examined with a microscope at magnifications of from 30 to 50 ×. The criteria for

determining a particular line pattern to be the finest pattern resolved were that all coarser patterns were resolved, and that the number of lines in a given pattern was the same as that of the corresponding pattern in the chart.

The average values for resolving power of the 4 lenses determined from a series of test runs showed that the position of the plane of best average definition is not affected by differences in target contrast nor by reversal in contrast between lines and background in the charts. Similarly, the values of measured resolving power are not affected by reversal of target contrast in low-contrast charts; however, the values of resolving power found with the low-contrast charts are approximately two-thirds of the values found with the high-contrast chart.

---

[1] *For further technical details, see* Location of the plane of best average definition with low contrast resolution patterns, *by Francis E. Washer and William P. Tayman, J. Research NBS* **65C** *(Eng. and Inst.), 195 (1961).*

[2] Method for determining the resolving power of photographic lenses, *by F. E. Washer and I. C. Gardner, NBS Circular 533 (1953), available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. ($1.75).*

[3] Precision camera for testing lenses, *by I. C. Gardner and F. A. Case, J. Research NBS* **18,** *449 (1937) RP984.*

1962 Electromagnetic Measurements Conference Announced

The 1962 International Conference on Precision Electromagnetic Measurements (formerly Conference on Standards and Electronic Measurements) will be held August 14, 15, and 16 at the NBS Boulder Laboratories.

This Conference is sponsored by the Radio Standards Laboratory of the National Bureau of Standards, the Professional Group on Instrumentation of the Institute of Radio Engineers, and the Instrumentation Division of the American Institute of Electrical Engineers. Previous conferences (1958 and 1960) each attracted more than 800 participants from industrial, university, and government laboratories throughout the world.

The change of name points up the basic aim of the Conference, which is the advancement of standards and accurate measurement throughout the coherent frequency spectrum. In addition, the 1962 Conference will give more emphasis to the impact of quantum electronics and space physics on precision electromagnetic measurements.

In its concern with the strictly technical aspect of measurement, this Conference will not include papers describing the large-scale organization and operation of standards laboratories (as did the conferences of 1958 and 1960). The interest in both fields is so great that the two subjects may not be adequately handled in a single conference. The second field, however, will be covered in a second conference which will closely precede (see page 17) the International Conference on Precision Electromagnetic Measurements.

The change in name also reflects the international aspects of the Conference. There are few if any other conferences with the same basic goal, yet there is a need to exchange such knowledge on a global basis and also to actively support and advance international standardization in the electromagnetic area. This need is evidenced by the fact that inquiries concerning the 1962 Conference have already been received from several laboratories in Europe.

Original papers in the following areas will be considered for presentation: (1) atomic frequency and time, (2) determination of conductivity and complex (tensor) electric and magnetic susceptibilities, (3) direct current and low frequency measurements, (4) radiofrequency and microwave measurements, (5) quantum electronics in precision measurements, (6) electromagnetic measurements for space exploration, and (7) data reduction in precision measurements.

Titles and summaries will be accepted in English or French but papers will be published in English. As before, it is planned to publish a conference record by including the conference papers in one issue of the IRE Transactions on Instrumentation.

Papers should be submitted to: Dr. George Birnbaum, Hughes Research Laboratory, Malibu, Calif. These should be in the form of 500- to 1,000-word summaries.

The deadline for submission of summaries is March 15, 1962. Notifications of acceptance or rejection will be mailed by April 15, 1962. The full technical program will be announced about June 1, 1962. This, with the registration brochure, will be mailed to those attending the 1960 Conference, members of IRE–PGI, IRE–PGMTT, and AIEE Instrumentation Division.

Further details relating to the Conference, including registration forms (available about June 1), can be obtained by writing to James F. Brockman, National Bureau of Standards, Boulder, Colo.

Superconductivity Maintained Under High Magnetic Field

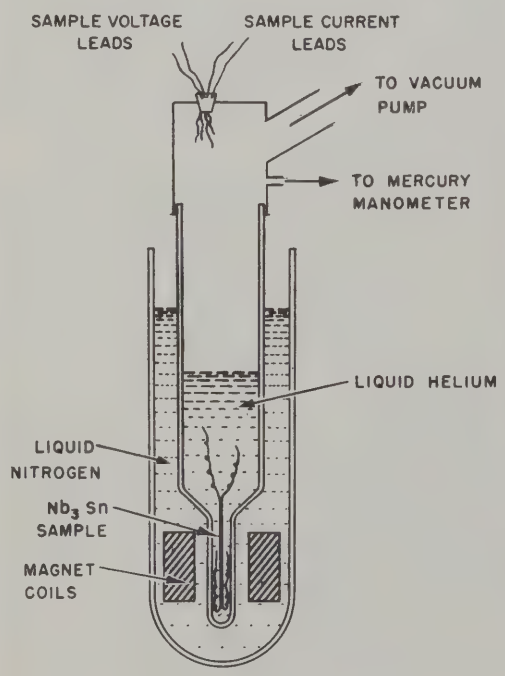
EXTREMELY HIGH magnetic fields are required in a large number of scientific applications, including deflectors in particle accelerators, solid state masers, adiabatic demagnetization experiments, and many others. Recent work [1] by the Bureau's Cryogenic Engineering Laboratory, Boulder, Colo., in cooperation with the Department of Physics, University of Colorado, may lead to the development of superconducting magnets having field strengths higher than any previously known. In a project sponsored by the Atomic Energy Commission, V. D. Arp, R. H. Kropschot, and J. H. Wilson of NBS, and W. F. Love and R. Phelan of the University have shown that niobium-tin (Nb_3Sn) wire remains superconducting in pulsed fields of up to 185 kgauss. When extrapolated to zero measuring current, the critical field appears to be about 188 kgauss at 1.6 °K.

The electromagnets commonly used to provide high magnetic fields require tremendous power for their operation. By utilizing the phenomenon of superconductivity—the disappearance of electrical resistance in certain metals at very low temperatures—magnets having high fields and low power requirements can be constructed. Unfortunately, most metals lose their superconducting properties when exposed to a small magnetic field above a certain critical value. However, the development of new alloys, such as Nb_3Sn, has resulted in wires that remain superconducting even under very high field conditions.

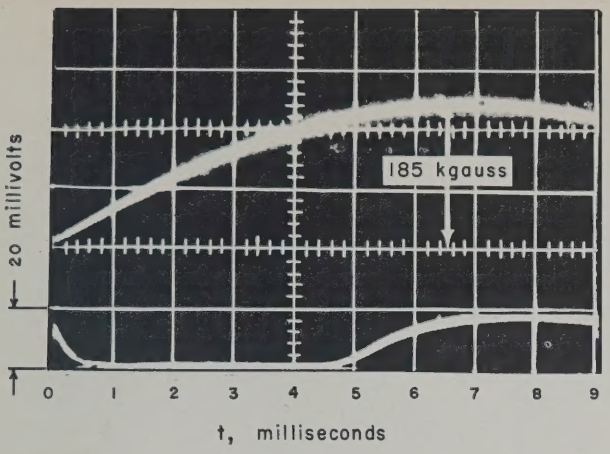
The Nb_3Sn wire used in this investigation was prepared in the Bureau's metallurgy laboratories following the procedure outlined by others [2] (who previously had produced Nb_3Sn wire which had remained superconducting in their highest available field of 88 kgauss), except that the wire was swaged rather than drawn to its final diameter of 0.50 mm. In brief, the preparation consisted of packing a niobium tube with a powdered Nb-Sn mixture, drawing or swaging the tube into wire, after which individual specimens, 12 cm long, were heat treated at 1,000 °C for 16 hr. The ends were acid-etched and tinned in a bath of molten indium after heat treatment. Current and potential leads were attached to the wire with indium solder.

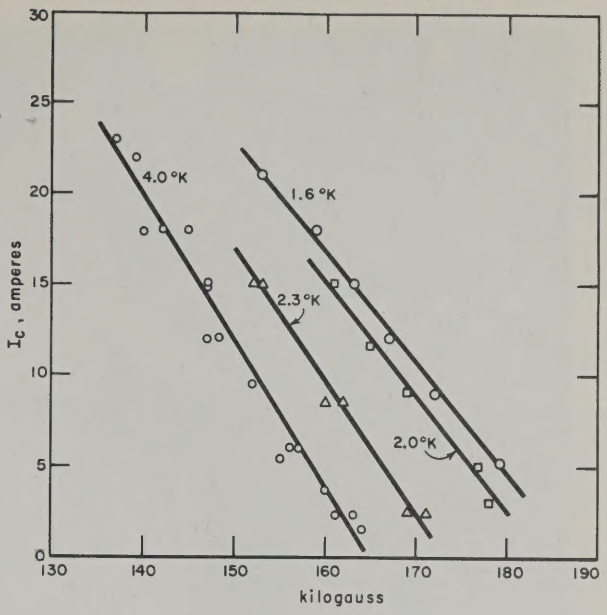
Measurements were made with the wire oriented parallel to the field of a pulsed magnet 6.4 cm long and 1.4 cm i.d., leaving the current and potential leads outside of the magnet. The wire was immersed in a liquid helium bath, and the magnet was placed in a surrounding bath of liquid nitrogen (left). The maximum current applied to the sample was 23 amp; 1,100 amp could be applied to the magnet. Ocilloscope traces of both magnetic field and the voltage across the wire provided a means of determining the critical field.

An example of the field-voltage results is shown on page 15. The upper trace is that of the magnetic field; a peak of 185 kgauss is reached in 7 msec. The lower trace shows the voltage across the sample; superconductivity is destroyed when the voltage returns. A transient voltage occurs when the field pulse is initiated. The results of a number of such measurements are presented in the figure on p. 15, in which critical current is plotted against critical magnetic field at various temperatures.



Simplified drawing of the apparatus used to determine the effects of pulsed magnetic fields on the superconducting properties of Nb_3Sn wire. Simultaneous oscilloscope traces of the magnetic field and of voltage across the wire permitted determination of the critical field, which appears to be 188 kgauss at 1.6 °K.





Above, **Oscilloscope record showing the relation of magnetic field to current in the sample. The upper trace is of magnetic field versus time, while the lower trace is of sample voltage (at 3 amp current) versus time. A transient voltage can be seen at the initiation of the magnetic field. Superconductivity is destroyed at the reappearance of a voltage.** *Right,* **Graph of critical current versus critical magnetic field for Nb_3Sn wire at several different temperatures.**

An estimate has been made of the eddy current heating of the sample during the field pulse. The results show that above the lambda point (2.17 °K) the sample might warm by as much as 1 deg K; below this temperature the rise should be less than 0.5 deg K. Also, the attenuation of the pulsed field through the sheath was calculated and found to be negligible.[3]

The use of Nb_3Sn wire in superconducting magnets requires knowledge of the critical field transverse to the current flow, rather than parallel as in these experiments. Therefore, the investigation will be continued in order to observe transverse critical fields. In addition, materials other than Nb_3Sn, such as solid solutions of NbZr, are being studied for possible use as superconducting magnets.

---

[1] *For further technical details, see* Superconductivity of Nb_3Sn in pulsed fields of 185 kgauss, *by V. D. Arp, R. H. Kropschot, J. H. Wilson, W. F. Love, and R. Phelan, Phys. Rev. Letters* **6,** *452 (May 1, 1961).*

[2] Superconductivity in Nb_3Sn at high current density in a magnetic field of 88 kgauss, *J. E. Kunzler, E. Buehler, F. S. Hsu, and J. H. Wernick, Phys. Rev. Letters* **6,** *89 (Feb. 1, 1961).*

[3] *A. M. Kosevich, J. Theor. Phys. U.S.S.R.* **33,** *735 (1958); Translation: Soviet Phys.-JEPT* **6,** *564 (1958).*

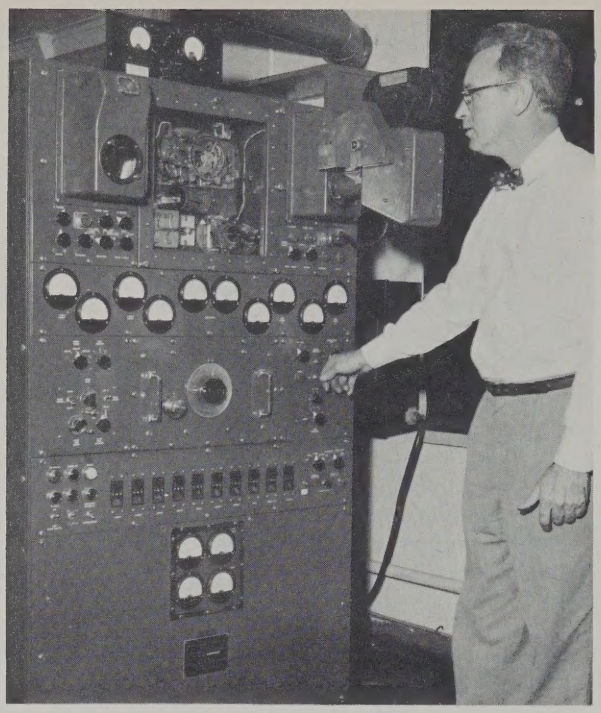
Estimating the Stage of the Sunspot Cycle

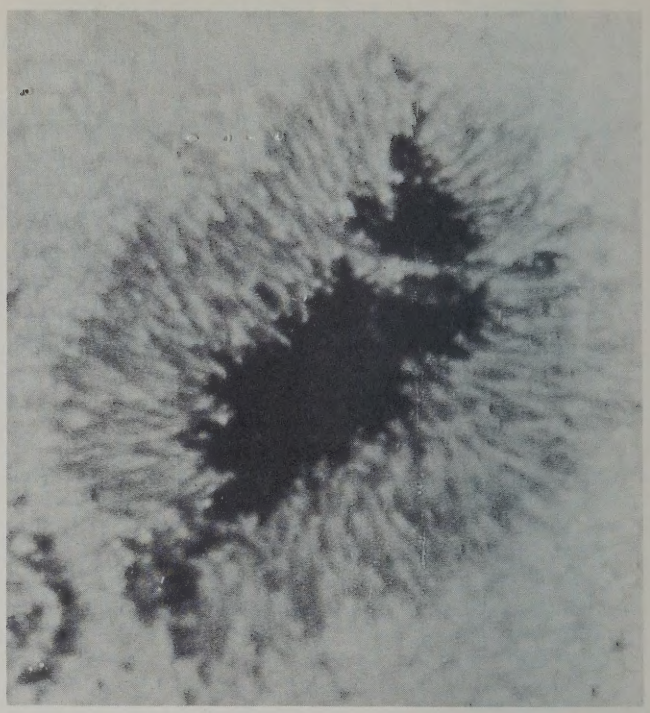
A SIMPLE, RAPID METHOD for estimating the stage of the sunspot cycle has been developed by W. B. Chadwick [1] of the Bureau's Central Radio Propagation Laboratory, Boulder, Colo. The method is based upon the relationship between the critical frequency [2] of the F_2-layer of the ionosphere and solar activity as measured by sunspot number. It is used to predict a smoothed annual sunspot number at the close of a given month, centered on that month. It should be especially valuable, in the period of the sunspot cycle shortly after the minimum, for giving an early indication of the level and timing of the coming maximum. However, it cannot be used, as is the earlier McNish-Lincoln [3] method, for predicting sunspot numbers for a given month in advance of that month.

The use of f_0F_2 as an indication of solar activity is not new, but this method is less complex than the methods so far proposed. By using maximum f_0F_2, rather than f_0F_2 for a particular time of day, it is felt that seasonal effects will be minimized.

A knowledge of the stage of the sunspot cycle is of importance in the field of long-distance radio communications. Such communications are made possible by the reflection of radio waves from the ionosphere, especially the uppermost or F_2 layer. However, the ability of the F_2 layer to reflect radiowaves is dependent upon the number of ions present—the higher the concentration of ions, the higher the frequency that can be reflected. These ions are created by radiation coming from the sun, and are more numerous during periods of high solar activity.

Sunspots—areas of relatively cool gases which appear as dark spots against the hotter regions of the sun's surface—have been observed and counted for well over 100 years. The Wolf sunspot number, published by the Zurich (Switzerland) Observatory, is obtained





Left, **J. J. Sullivan of the NBS Fort Belvoir, Va., field station, adjusts the C–3 ionospheric recorder used to determine the critical frequency of the ionosphere. Critical-frequency data are used in a Bureau-developed method for determining the stage of the sunspot cycle.** *Right,* **sunspot photographed from a balloon at an altitude of 80,000 ft. The large amounts of ultraviolet radiation associated with sunspot activity affect long-distance radio communications.** (*Photo courtesy Office of Naval Research.*)

---

by multiplying the number of visible sunspot groups by 10 and adding to this product the total number of individual spots observable; the result is dependent also upon observatory constants used as factors to bring the observations into best general consistency with R. Wolf's original observations. The sunspot number follows roughly an 11-yr cycle, with the height of the maximum and depth of the minimum varying from cycle to cycle. At times during the minimum the monthly sunspot number is zero for months at a time; during maximums, daily values may run as high as several hundred.

The critical-frequency data used in making an estimate with this method are the maximum median hourly values of f_0F_2, as determined month by month at the Bureau's Ft. Belvoir (Va.) field station, although data from any station that has operated consistently for a number of years could be used. A record of ionospheric reflection of a vertical-incidence beam, swept from 1–25 Mc/s, is presented on a cathode ray tube and photographed with a C–3 recorder. The frequency on the record at which the trace becomes vertical is the critical frequency.

The various correlation coefficients between sunspot number and critical frequency as observed at Ft. Belvoir [1] are quite high, ranging, over the years considered, from a low of 0.89 to a high of 0.989. The sunspot number-critical frequency data were used to create a series of linear regression equations, one for each month, which enable the calculation of the estimated 12-month running average sunspot number from the critical frequency data.

---

[1] *For further details, see* A quick method for estimating the stage of the sunspot cycle, *by W. B. Chadwick, J. Research NBS (Radio Prop.)* **65D,** *No. 6, 637 (Nov.–Dec. 1961).*

[2] *The critical frequency is that frequency below which the ionospheric layer being studied will reflect back to earth all frequencies and above which the frequencies pass through the layer. For further information on sunspot-critical frequency relationships, see* Ionospheric radio propagation, *NBS Circular 462, available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (Price $1.25).*

[3] Prediction of sunspot numbers, *by A. G. McNish and J. V. Lincoln, Trans. Amer. Geophys. Union* **30,** *673 (Oct. 1949). This method is based upon the mean value of previous sunspot numbers for a similar point on the cycle. See also* Statistical method of predicting sunspots aids radio propagation forecasts, *NBS Tech. News Bull.* **31,** *99 (Sept. 1947).*

National Conference of Standards Laboratories Established

Announces First Meeting for August 1962

To help meet the needs of science and industry for improved uniformity and greater precision in calibration and measurements in all areas of the physical sciences, engineering, and technology, a new organization—the National Conference of Standards Laboratories (NCSL)—was established on September 15, 1961 by representatives concerned with standards activities in Government, industry, education, and professional societies. One of the major activities of the NCSL will be to arrange a continuing series of standards laboratory conferences. The NCSL's General Committee, headed by Lloyd B. Wilson of the Sperry Gyroscope Company, has scheduled the first conference in this series for August 8–10, 1962 at the NBS Boulder Laboratories, Boulder, Colo. Another major activity being considered is the establishment of a voluntary system of measurement-agreement checks to demonstrate competence and continued uniformity among standards laboratories.

Standards and calibration activities have registered a significant increase in recent years, led by "space-age" industries. The expansion of activity has stimulated surveys of present and anticipated calibration requirements and measurement problems, growth in size and numbers of standards laboratories within private industry, and establishment by the military of extensive systems of standards laboratories at various echelons between the Bureau and the weapons, radar, communications, and transport systems at the point of use.

The National Conference of Standards Laboratories is an outgrowth of a number of discussions, meetings, and studies carried out by an Ad Hoc Committee set up in June 1960 at a Conference on Standards and Electronic Measurements held in Boulder, Colo. NCSL was established in Los Angeles at a Standards Laboratory Conference arranged by the Ad Hoc Committee and held concurrently with the Instrument Society of America's Annual Conference. More than 125 persons participated in the organization meeting.

The objectives of the NCSL are to:

1. Determine the requirements of science and industry for greater precision in measurement.
2. Increase the over-all competence of standards laboratories by the development of uniform practices relating to organization, staffing, and operation.
3. Provide opportunity for voluntary participation in measurement agreement operations to demonstrate competence and continued uniformity among standards laboratories.

Discussions at the September 15, 1961 Standards Laboratory Conference in Los Angeles, together with questionnaires filled out by the attendees, indicated the need for action in a number of specific areas, as follows:

(a) Calibration "traceability" and measurement agreement
(b) Evaluation, selection, and training of measurements standards personnel
(c) Standards laboratory workload control
(d) Calibration procedures, techniques, and specifications
(e) Small standards laboratory operations
(f) Corporate standards laboratory organization and operation
(g) Calibration equipment evaluation techniques
(h) Design and construction of calibration rooms
(i) Calibration reliability and quality control
(j) Calibration cost reduction, cost justification, and value analysis
(k) Calibration terminology and definitions
(l) Liaison measurement standards and calibration equipment needs.

NCSL special committees are being set up in many of these subject areas. The activities of these committees will be pursued at a series of Standards Laboratory Management Workshops as well as at the August 1962 Standards Laboratory Conference.

The NCSL is a standards laboratory-oriented organization; its efforts will be directed towards solving the problems faced by standards laboratories in their organization and operation. Industrial labs and companies which have standards laboratories will soon be issued invitations to become members. Scientific societies and government organizations which have an interest in this field will be asked to become sponsors. Other organizations which indicated an interest in NCSL at the time it was formed included the National Bureau of Standards, Department of Defense, Instrument Society of America, Precision Measurement Association, American Society for Testing Materials, American Standards Association, and the Institute of Radio Engineers.

The National Conference of Standards Laboratories is not intended to be an organization which will duplicate work of existing organizations. Instead, it will cooperate actively with such existing organizations by calling their attention to the problems faced by the standards laboratories and by requesting these organizations to take whatever action they can to assist in solving these problems. In areas where the need is urgent and where suitable assistance cannot be obtained, the NCSL will undertake solutions on its own.

Organizing of the NCSL and planning of NCSL action projects is being handled by a General Committee. Officers are Lloyd B. Wilson, Chairman (Chief, Primary Standards and Measurements, Sperry Gyroscope Company, Great Neck, N.Y.); Charles E. Johnson, Vice-Chairman (Senior Group Engineer, Primary Standards Laboratory, Boeing Company, Seattle, Wash.); and Harvey W. Lance, Secretary (Chief, Electronic Calibration Center, Boulder Laboratories, National Bureau of Standards, Boulder, Colo.).

UNITED STATES
GOVERNMENT PRINTING OFFICE
DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25, D.C.

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, $300
(GPO)

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Volume **45**, No. 12, December 1961. 15 cents. Annual subscription: $1.50. 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Basic Radio Propagation Predictions for March 1962. Three months in advance. CRPL–208, issued December 1961. 15 cents. Annual subscription $1.50, 50 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75.

Section D. Radio Propagation. Issued six times a year. Annual subscription: Domestic, $4; foreign, $4.75.

Nonperiodicals

An experimental study of phase variations in line-of-sight microwave transmissions, K. A. Norton, J. W. Herbstreit, H. B. Janes, K. O. Hornberg, C. F. Peterson, A. F. Barghausen, W. E. Johnson, P. I. Wells, M. C. Thompson, Jr., M. J. Vetter, and A. W. Kirkpatrick, NBS Mono. 33 (Nov. 1, 1961) 55 cents.

Tables of chemical kinetics. Homogenous reactions (supplementary tables), NBS Mono. 34 (Sept. 15, 1961) $2.75.

Bibliography and index on vacuum and low pressure measurement, W. G. Brombacher, NBS Mono. 35 (Nov. 10, 1961) 60 cents.

Effect of mortar properties on strength of masonry, C. C. Fishburn, NBS Mono. 36 (Nov. 20, 1961) 30 cents.

Tabulation of data on microwave tubes, C. P. Marsden, W. J. Keery, and J. K. Moffitt, NBS Handb. 70 (Nov. 1, 1961) $1.00.

Technical Notes

The following Technical Notes are available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (Order by PB number.)

Mean electron density variations of the quiet ionosphere, No. 6—August 1959, J. W. Wright, L. R. Wescott, and D. J. Brown, NBS Tech. Note 40–6 (PB151399–6) (1961) $1.50.

Techniques for computing refraction of radio waves in the troposphere, E. J. Dutton and G. D. Thayer, NBS Tech. Note 97 (PB161598) (1961) $1.50.

Performance predictions for single tropospheric communication links and for several links in tandem, A. P. Barsis, K. A. Norton, P. L. Rice, and P. H. Elder, NBS Tech. Note 102 (PB161603) (1961) $3.00.

Astrophysical and plasma physics research at the National Bureau of Standards, Highlights for 1961, L. M. Branscomb, K. E. Shuler, J. A. Suddeth, NBS Tech. Note 116 (PB161617) (1961) ($1.00).

Variations in frequency of occurrence of sporadic *E*, 1949–1959, W. B. Chadwick, NBS Tech. Note 117 (PB161618) (1961) 75 cents.

Publications in Other Journals

Repulsion of energy levels in complex atomic spectra, R. E. Trees, Phys. Rev. **123**, No. 4, 1293–1300 (Aug. 15, 1961).

Parameters α and β in the spectra of the iron group. R. E. Trees and C. K. Jorgensen, Phys. Rev. **123**, No. 4, 1278–1280 (Aug. 15, 1961).

Slow drift solar radio bursts: harmonic frequency ratios, solar longitude dependence, and frequency drift rates, M. B. Wood, Australian J. Phys. **14**, No. 2, 234–241 (1961).

Infrared spectrum and structures of the NF_2 radical, M. D. Harmony, R. J. Myers, L. J. Schoen, D. R. Lide, Jr., and D. E. Mann, J. Chem. Phys. **35**, No. 3, 1129 (Sept. 1961).

Fibrous silica, W. Haller, Nature **191**, No. 4789, 662–663 (Aug. 12, 1961).

Control terminology—A report on U.S. standards activity, H. L. Mason, Control Eng. **8**, No. 10, 67–70 (Oct. 1961).

Behavior and evaluation of rubber, R. D. Stiehler, Am. Concrete Pipe Assoc. Tech. Memo. (Oct. 1961).

Statistical dynamics of simple cubic lattices. Model for the study of Brownian motion II, R. J. Rubin, J. Math. Phys. **2**, No. 3, 373–386 (May–June 1961).

Partial confounding in fractional replication, W. J. Youden, Technometric **3**, No. 3, 353–358 (Aug. 1961).

Welded butt joints with fine wires, L. Martz, Rev. Sci. Instr. **32**, No. 8, 990–991 (Aug. 1961).

Systematic errors in physical constants, W. J. Youden, Physics Today **14**, No. 9, 32–34, 36, 38, 40, 42 (Sept. 1961).

Mass spectrometric study of the thermal dissociation of N_2F_4, J. T. Herron and V. H. Dibeler, J. Chem. Phys. **35**, No. 2, 747–748 (Aug. 1961).

A study of solar activity associated with polar cap absorption, (abstract) C. S. Warwick and M. B. Wood. Polar Cap Absorption Conf. (Kiruna, Sweden, Aug. 8–11, 1960), Arkiv Geofyski **3**, No. 21, 457 (1960).

Patents

(The following U.S. patents have recently been granted on NBS inventions. Except as noted, these patents are assigned to the United States of America as represented by the Secretary of Commerce.)

2,991,430 July 4, 1961. Automatic r-f level control. Charles M. Allred and Paul A. Hudson.

2,995,708 August 8, 1961. Dry static calorimeter for r-f power measurement. Charles M. Allred and Paul A. Hudson.

2,995,712 August 8, 1961. High-input-impedance transistor amplifier. George Franklin Montgomery.

2,997,652 August 22, 1961. Self-balancing d-c bolometer bridge. Glenn F. Engen.

2,998,193 August 29, 1961. Electronic analogue computers for radioactive fallout prediction. Harold K. Skramstad, Julius H. Wright, and Leonard Taback.

3,002,899 October 3, 1961. Adhesion of nickel to chromium. Walter E. Reid, Jr. (Navy).

3,005,332 October 24, 1961. Strain gage calibration device. Ralph M. McClintock.

Publications for which a price is indicated (except for Technical Notes) are available only from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (foreign postage, one-fourth additional). Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

NBS Technical News Bulletin

U. S. GOVERNMENT PRINTING OFFICE : 1962 O - 621939